No. 614,225. Patented Nov. 15, 1898.

# L. GUTMANN.

## ELECTRIC METER.

(Application filed Dec. 4, 1897.)

(No Model.)

2 Sheets—Sheet 1.

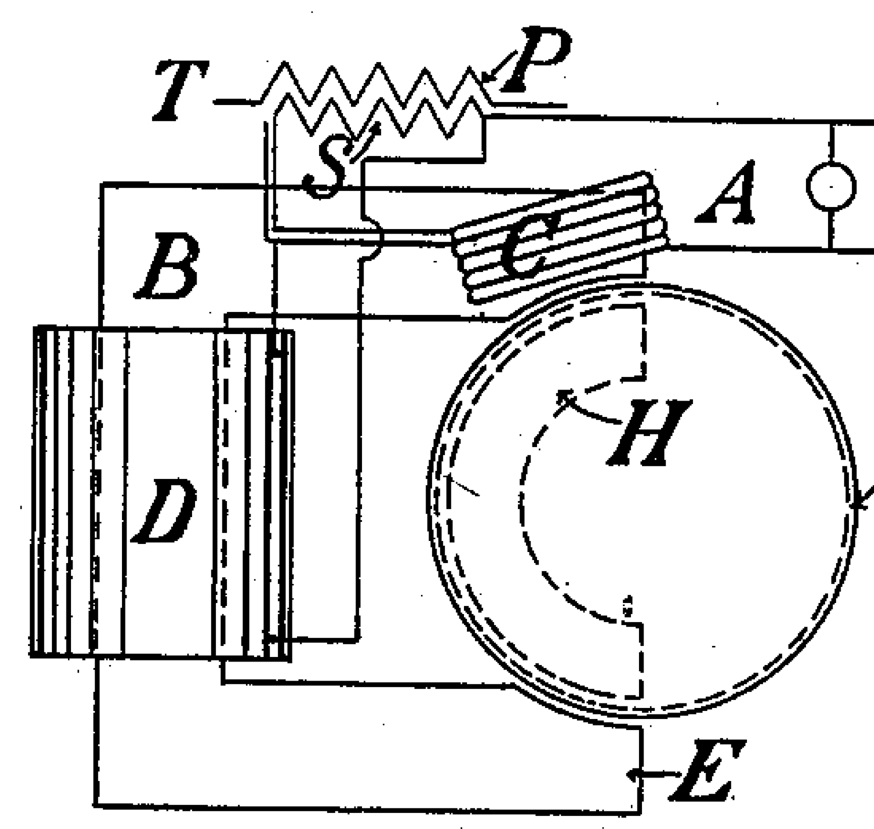



Fig. 1.

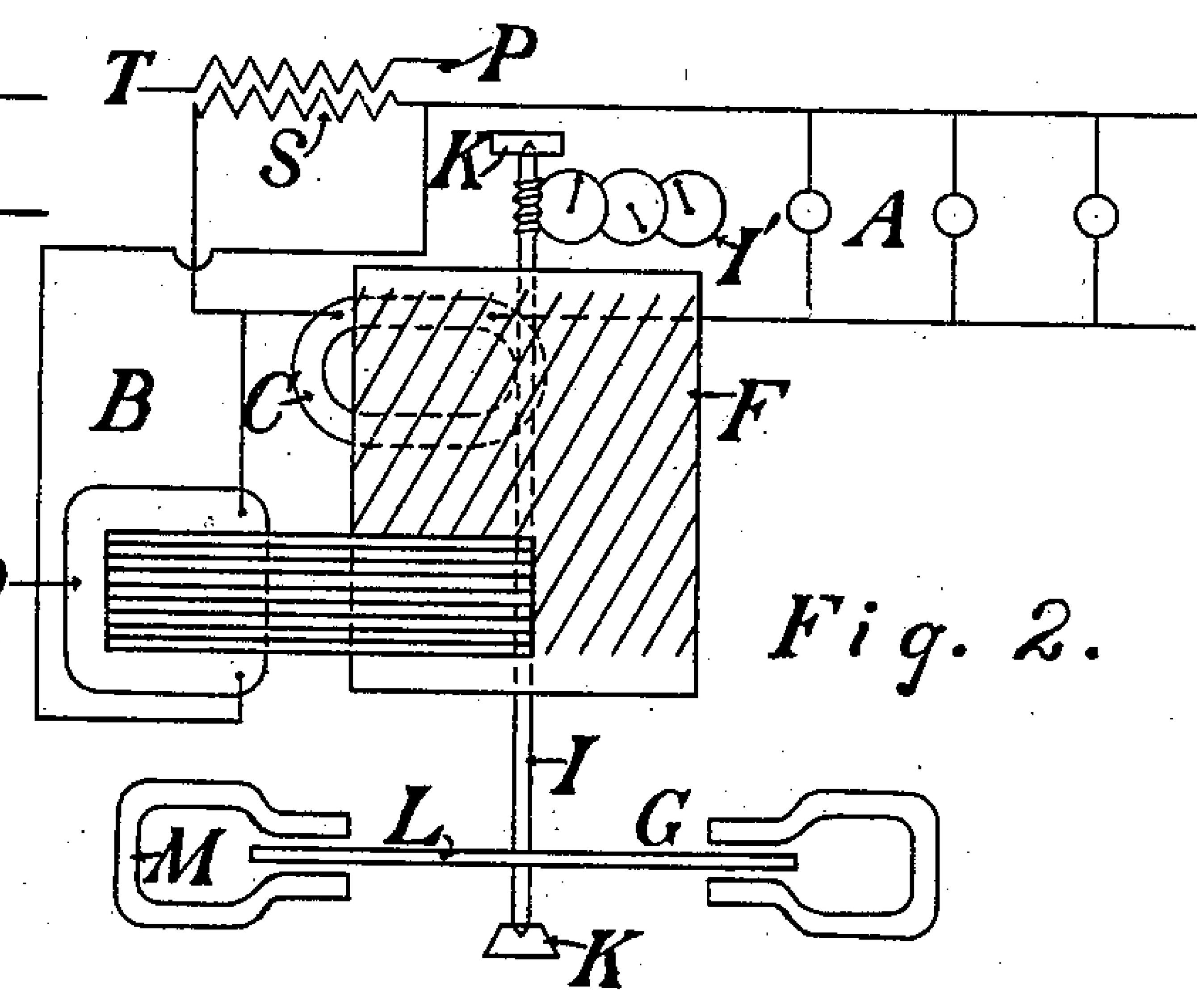



Fig. 2.

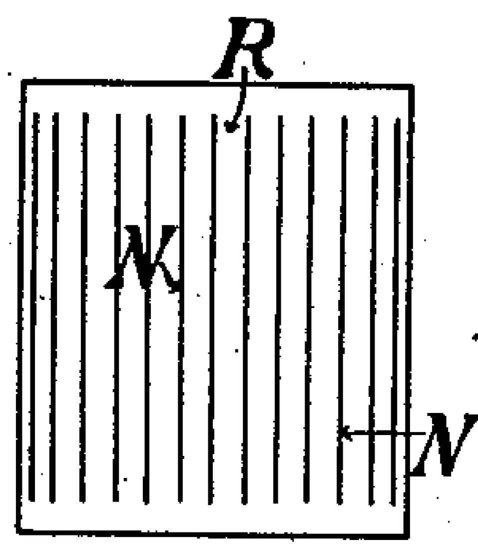



Fig. 3.

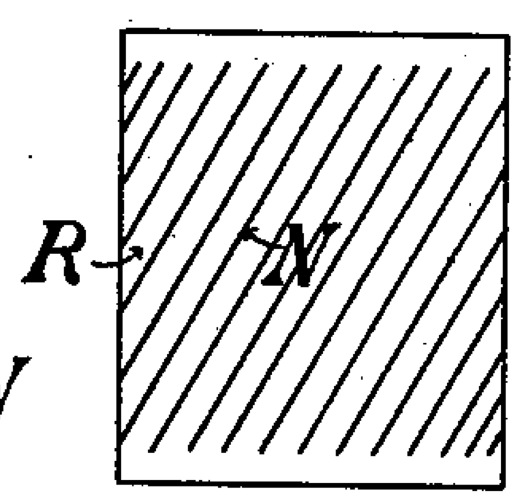



Fig. 4.

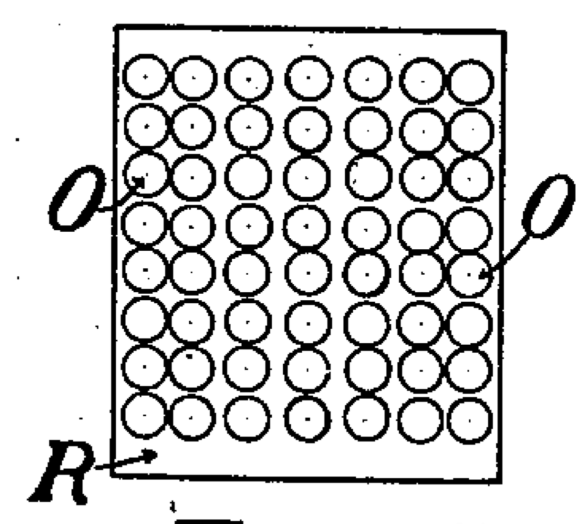



Fig. 5.

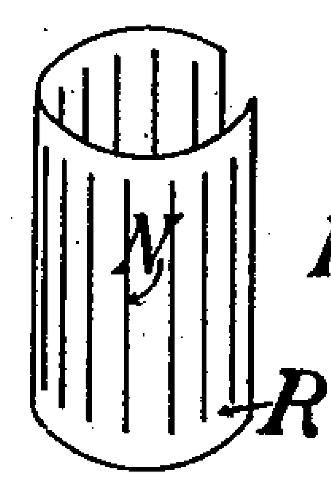



Fig. 6.

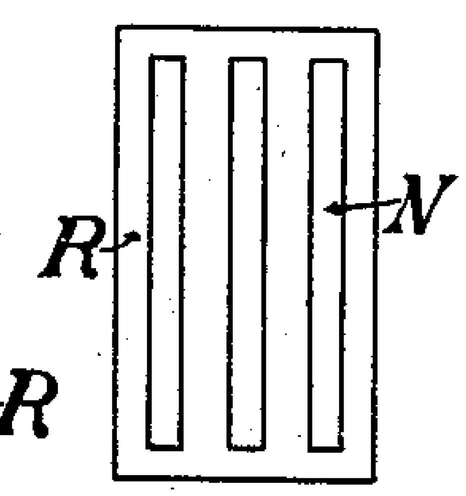



Fig. 6a.

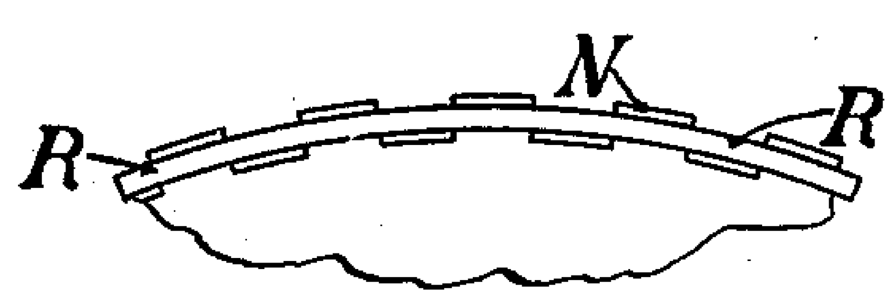
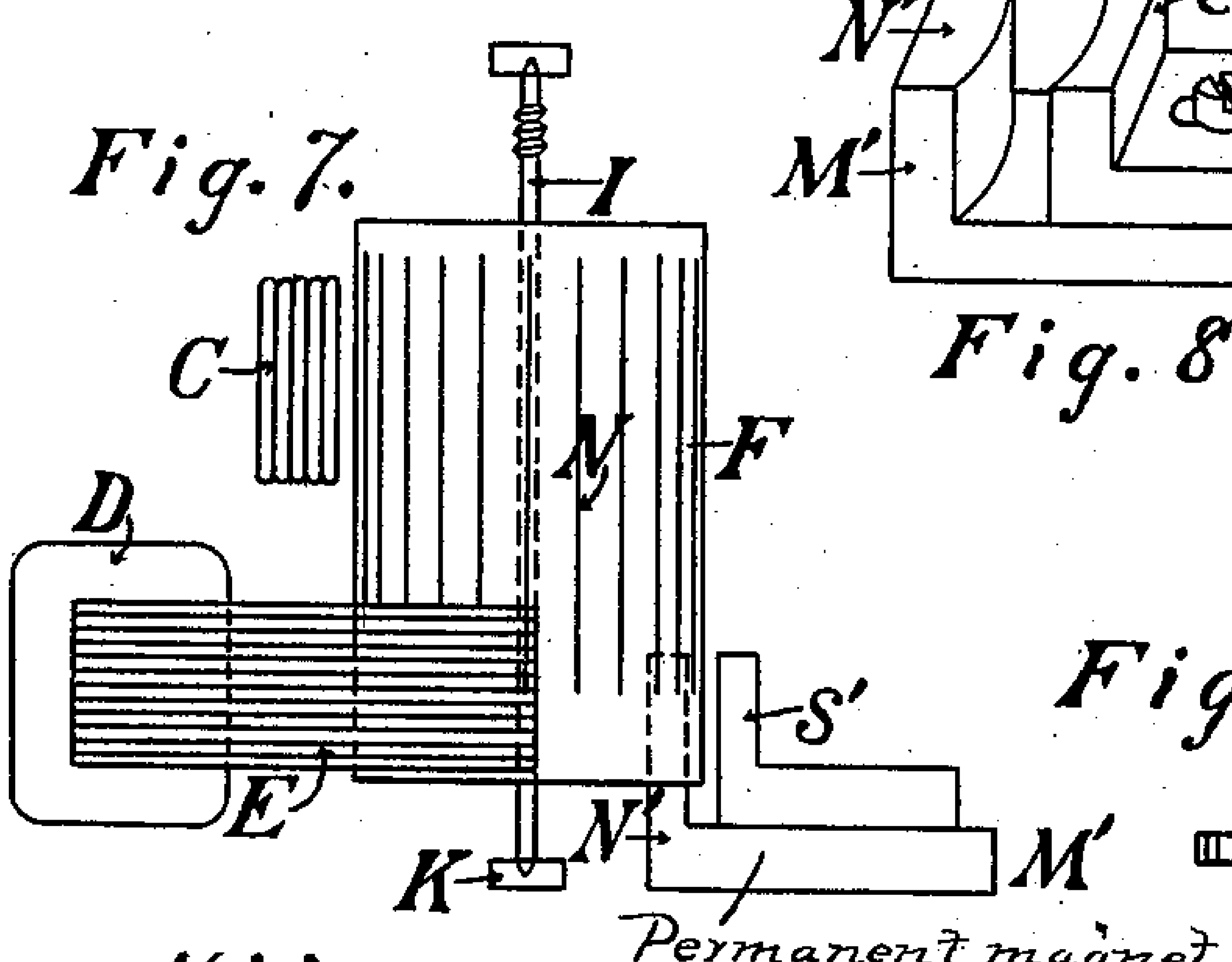



Fig. 6b.

Fig. 7.



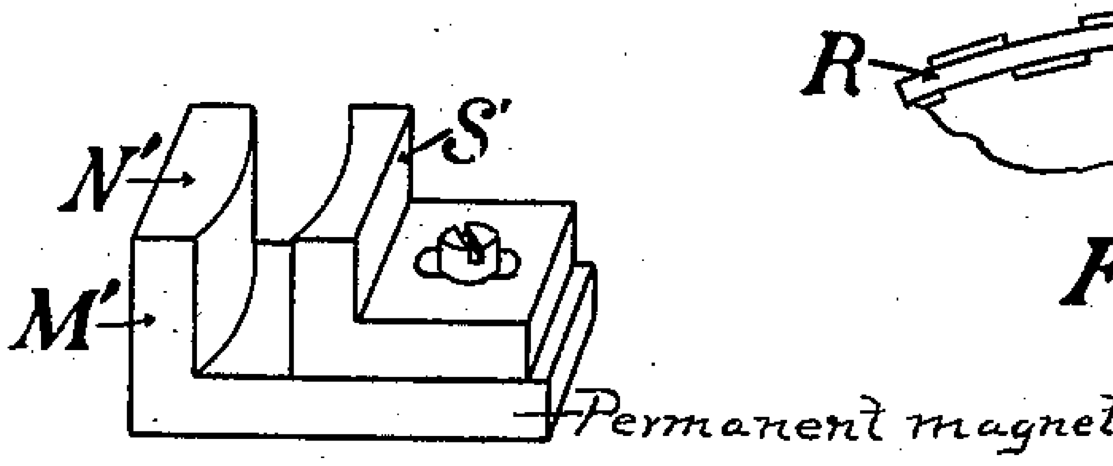




Fig. 8.

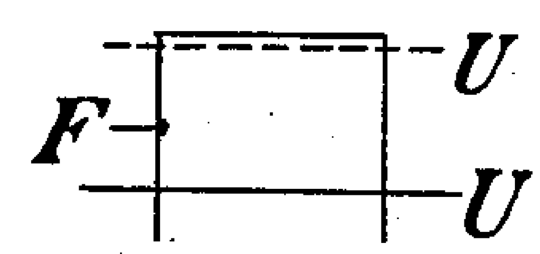
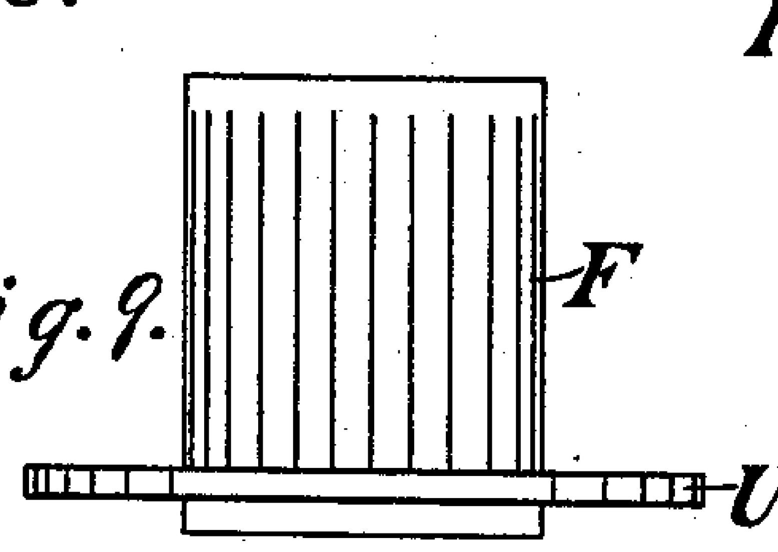



Fig. 9a.

Fig. 9.




Witnesses:-

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George A. Bates

Inventor:-

Ludwig Gutmann.

No. 614,225.

**Patented Nov. 15, 1898.**

## L. GUTMANN.

## ELECTRIC METER.

(Application filed Dec. 4, 1897.)

(No Model.)

2 Sheets—Sheet 2.

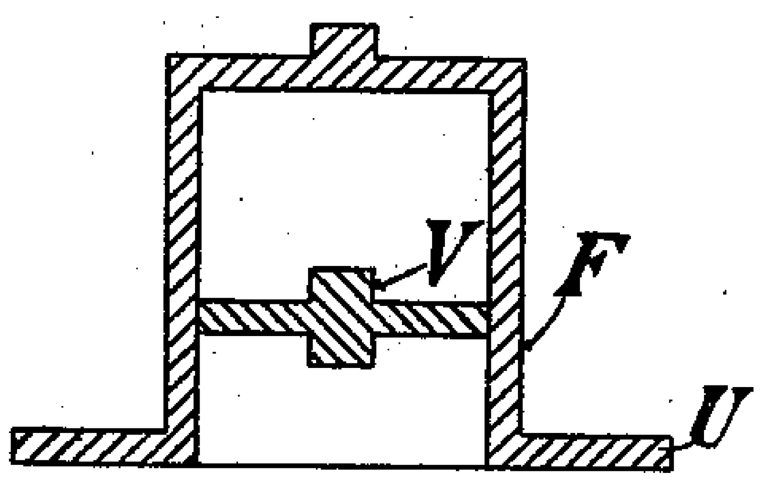


*Fig. 10.*

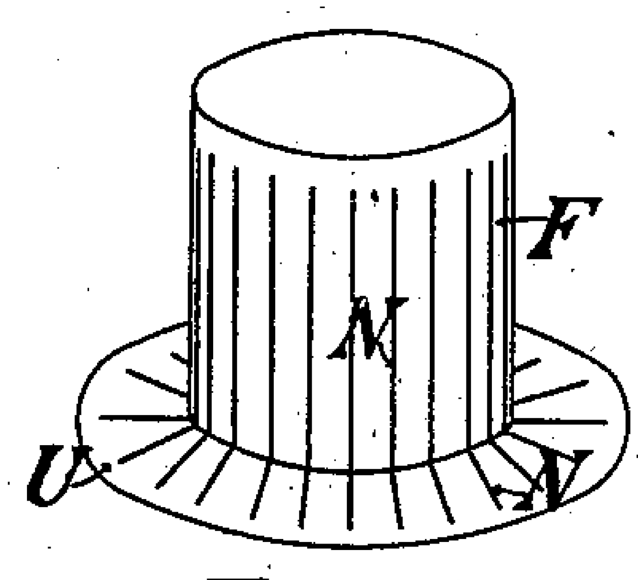


*Fig. 11.*

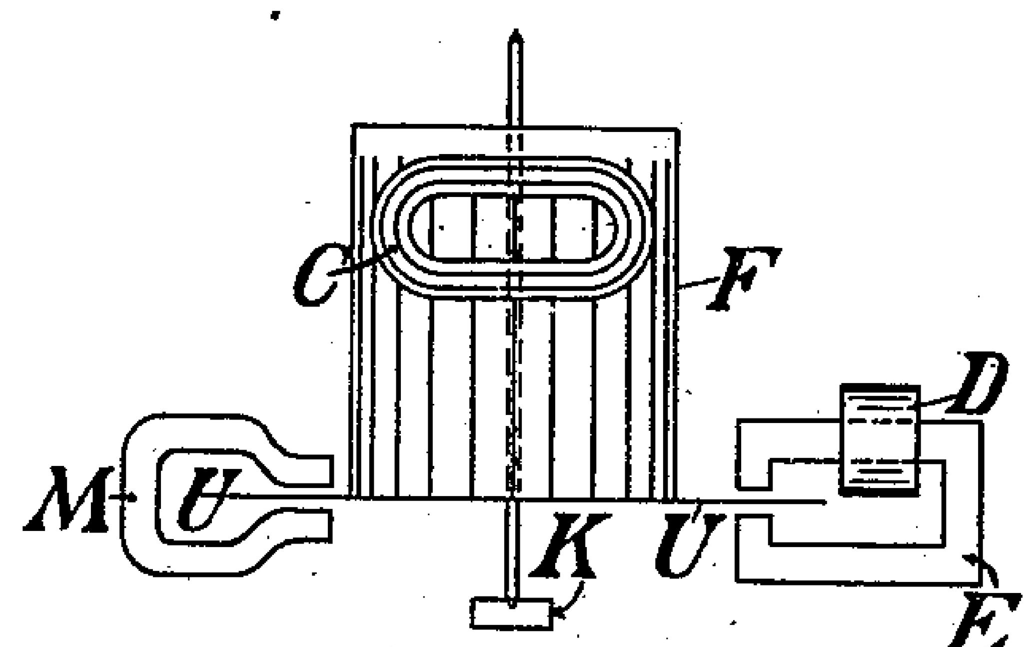


*Fig. 12.*

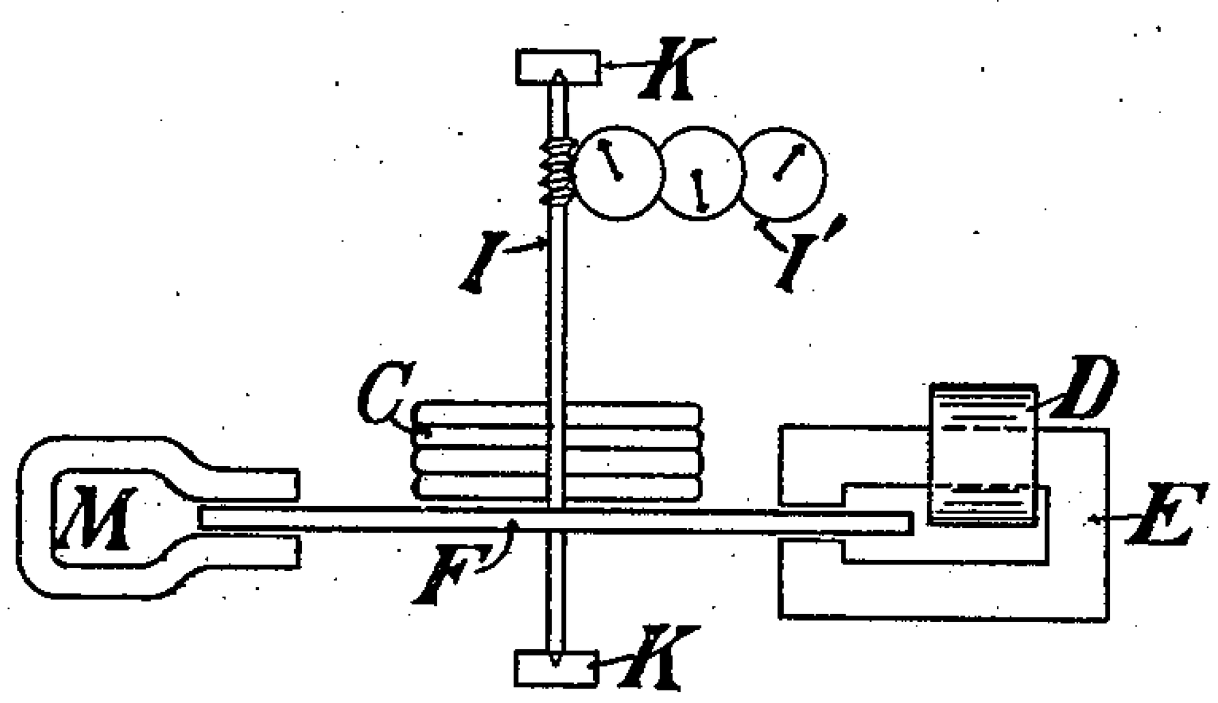


*Fig. 13.*

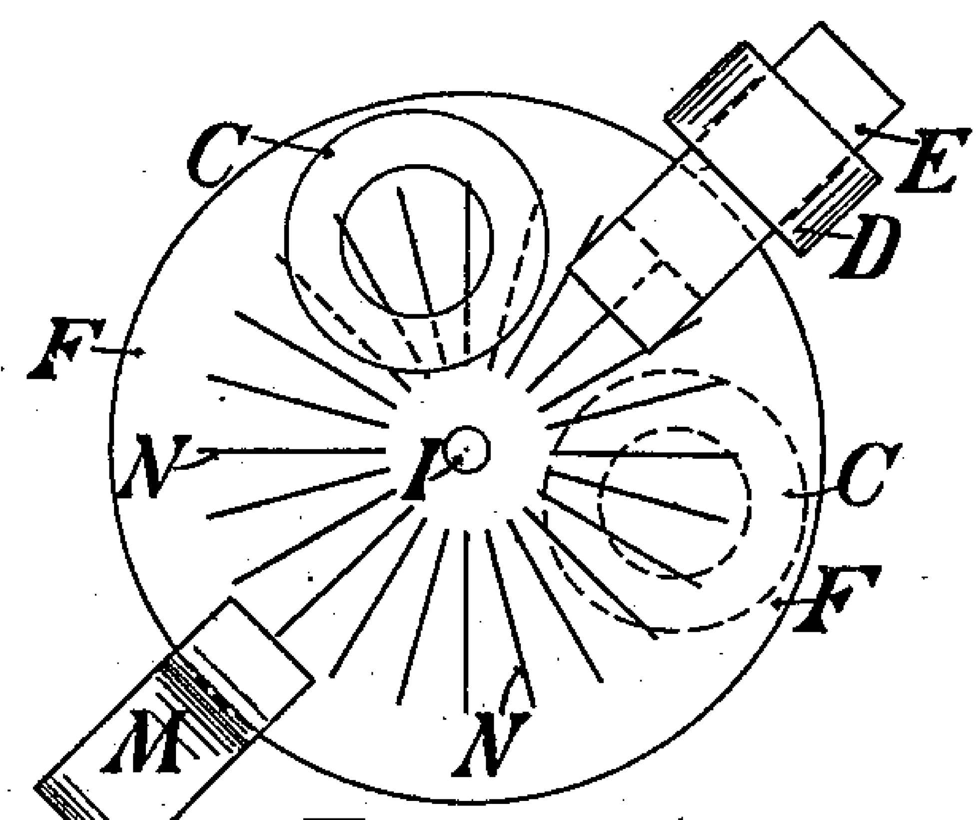


*Fig. 14.*

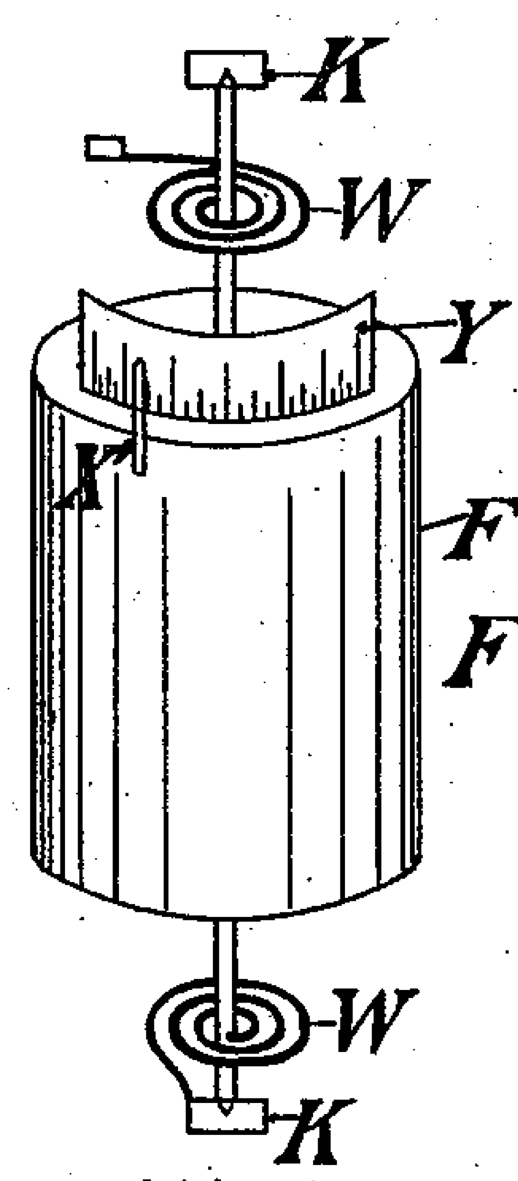


*Fig. 15.*

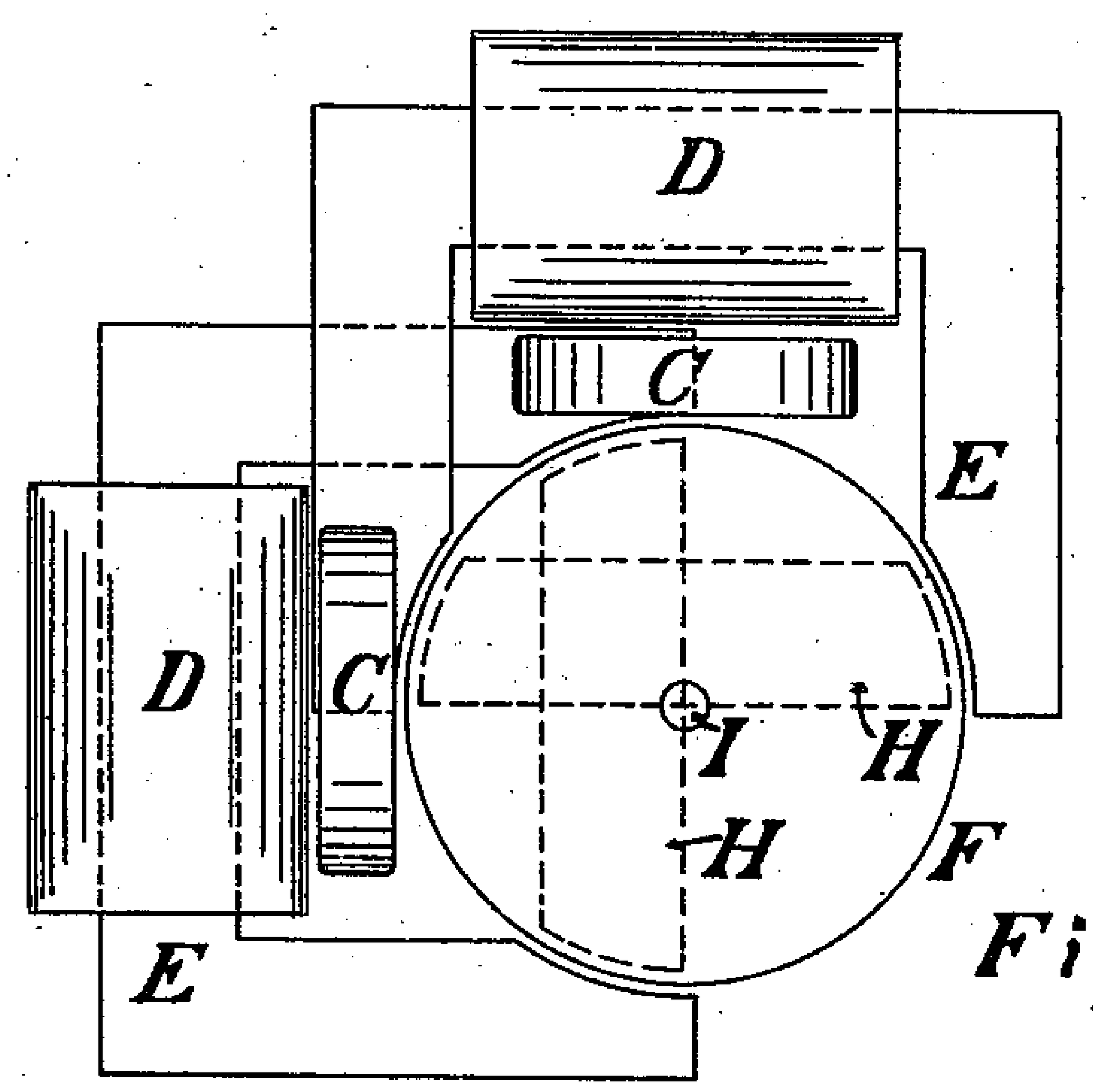


*Fig. 16.*

*Witnesses:-*

*Inventor:-*

Ludwig Gutmann

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

# UNITED STATES PATENT OFFICE.

LUDWIG GUTMANN, OF PEORIA, ILLINOIS.

## ELECTRIC METER.

SPECIFICATION forming part of Letters Patent No. 614,225, dated November 15, 1898.

Application filed December 4, 1897. Serial No. 660,767. (No model.)

*To all whom it may concern:*

Be it known that I, LUDWIG GUTMANN, a citizen of the United States, and a resident of the city of Peoria, county of Peoria, and State of Illinois, have invented new and useful Improvements in Electric Meters and Motors, (Case No. 89,) of which the following is a specification.

My invention relates to electric meters and motors, and especially those to be operated by alternating, pulsating, or intermittent currents.

My invention relates in particular to an armature especially adapted for meters as well as for alternating power-motors; and it further relates to certain dispositions and improvements in meter registering and regulating devices. The improvement of the armature is both mechanical as well as electrical. The disposition of slanting the conductors considerably increases the firmness of the cylinder as compared with that of other perforated forms, while from an electrical and magnetic standpoint its sensitiveness is considerably increased and adapted to produce a torque with given dispositions of energizing-coils where other armature constructions fail. The meter belongs to the motor-meter type, and therefore the points of superiority which will be described in particular for the meter can be used with the same effect for motors, though it is not intended to go into any description of motor design. The use of the armature for power-motors will be self-evident.

In alternating-current meters it has been the practice to utilize in most instances a uniform ring or cylinder which is acted upon by currents of displaced phases whose planes intersect one another. The currents induced on the surface of these rings or cylinders are considered to be of the nature of eddy-currents. I have discovered that far more sensitive and more powerful results can be obtained if a metallic cylinder, such as copper or aluminium, is so organized that secondary currents induced therein may have a defined path which they have to follow in their excursion.

In all meters at present in use a magnet-core is within the path of the lines of force of the series winding, or else several coils are placed so that the flux of one threads the convolutions of the other, causing an increased self-induction in the main coil, which I have found to be detrimental for wide-range meters. The meter is as well adapted for a coulomb-meter as a wattmeter. To register watts, it is well known in the art that the pressure of the line as well as the current consumed must be measured for indicating as well as integrating instruments. It is therefore evident that in alternating-current meters of this kind two circuits are always required. The proper proportioning of these two circuits is of great importance for sensitive instruments having a wide range.

To describe the invention more fully, it is explained with reference to the accompanying drawings, in which—

Figure 1 shows in diagram the meter in a lamp-circuit. Fig. 2 is a diagram of the meter in elevation in a lamp-circuit and provided with a suitable retarding device. Figs. 3, 4, and 5 are preferred types of armatures or armature-windings. Figs. 6, 6[a], and 6[b] are modifications of the winding for power-motors. Fig. 7 is a further improvement over Figs. 1 and 2. Fig. 8 is a detailed view of the permanent magnet used in connection with Fig. 7. Figs. 9, 9[a], 10, 11, 12, 13, and 14 are further armature modifications showing other preferred types. Fig. 15 shows in diagram the application of this armature to an indicating instrument. Fig. 16 shows the application of the meter to two-phase circuits.

This device is an evolution of my meter, Patent No. 543,089, of July 23, 1895, in which closed secondary circuits are employed in the armature.

Referring in particular to Fig. 1, the transformer T has its primary P connected to any suitable source, which for convenience has been omitted. The secondary of the transformer S is connected to the lamp-circuit A, into which is inserted the meter B. The meter is of the wattmeter type, and has in its simplest form a single series coil C and a single shunt-coil D, the coil C being interposed in one side of the circuit between the transformer secondary and the lamps, while the shunt-coil D is connected across the transformer-terminals. Both these coils act on a special armature F. To produce a considerable difference in phase, the coil D is mounted on a laminated magnet E, which embraces the armature F, while the coil C, on the other hand, has preferably no iron in its magnetic circuit. This enables me to produce a minimum self-induction of the lamp-circuit and in the coil carrying the current to be measured. To increase still further the difference in phase of the series and shunt coils C and D, which I have found not only desirable, but essential for a proper meter, the magnetic resistance of magnet E is considerably reduced by interposing the crescent core H, which is normally located inside of the bell-shaped armature F. Its sole purpose is to reduce the magnetic resistance in the magnet-circuit and to increase the difference in phase between series and shunt circuit.

Fig. 2 shows the general organization in elevation. The coil C is shown in series connection with the lamp-circuit A and in this figure is partially covered by the armature F. Below the coil C is shown the magnet E and coil D, while the crescent core H, lying between the poles of the magnet, is invisible. The armature F is mounted on shaft I, which rests in bearings K K. A retarding device G is applied and consists of the disk L and magnets M. The disk may be rigidly attached or else geared to the shaft *l*, which latter engages with the counting-train *l'*.

It will be seen from the description of Figs. 1 and 2 that contrary to most meters of this kind operated by currents of displaced phases the fields of the energizing-coils do not intersect with one another.

I have discovered that a far more sensitive meter can be constructed and stronger torque obtained if the induced currents in the armature flow in predetermined paths. This mode differs widely from that of Shallenberger and Ferraris, in whose armatures the currents induced are of the nature of Foucault currents. In connection with such an armature I prefer to use a series coil of few turns and little or no iron in its magnetic circuit and a shunt-coil with a high self-induction and as nearly a closed magnetic circuit as possible. Without this latter condition experiments show such meter to be less reliable, while in addition its range is considerably reduced. Furthermore, the relation of the coil, magnet-poles, and the strips caused by the slots have influence on the operation. If, for instance, the coil and the magnet be small and but two or four slots are cut in a cylinder forming conductors twice as wide as a coil or magnet or even as wide, there is very little difference between such armature and a solid conductor such as the Ferraris armature, and its operation would be irregular. I have found, further, that by giving the conducting-strips R a slanting or non-radial position with respect to the plane of rotation the armature will start more promptly in one direction than in the opposite one.

My preferred style of armature consists of a cylinder which is provided with slots or holes, as shown in Figs. 3, 4, and 5. These armature types are equivalent to windings, and owing to the slots N or holes O the currents induced by the coils C flow along the narrow conductors or bands R and react upon the magnet E, or vice versa. It will be evident that this style of winding or armature conductors, Figs. 3 and 4, is just as applicable to induction-motors for power purposes as to meters. These windings may be used either without an iron core, with a smooth iron core, or a toothed one. In the latter case the teeth project through the slots N. (See Fig. $6^b$.) This style of armature can be economically constructed by perforating a straight piece of metal and bending the same into a cylinder either by using a single piece of metal, Fig. 6, or several pieces of metal, Fig. $6^a$, which may be joined together to form a single cylinder. This latter process may be preferred when using this style of winding for power-motors. The material used for these armature windings or cylinders may be brass, copper, aluminium, or any other suitable metal and may be mounted in sections on a toothed core and finally connected at the ends or left independent.

Fig. 7 shows a further modification over Figs. 1 and 2. The improvement consists in omitting the disk L of the retarding device by utilizing a portion of the cylinder F for this very purpose. In Fig. 7 the cylinder F, coil C, and magnet E have not exactly the same relation to one another as in Figs. 1 and 2; but it will be observed that the slots N shown in the cylinder are in a vertical direction; further, they do not reach the lower end of the cylinder, which constitutes an uninterrupted conductor or metallic cylinder. This portion of the armature is exposed to the magnetic field of the horseshoe-magnet M', which preferably is adjustable with relation to the armature F. To be able to properly adjust the speed of the rotating armature and obtain a low speed proportional to the watts consumed, it is desirable to control and vary or adjust the strength of magnet M'. This is accomplished by moving the poles of the magnets relatively to one another, Fig. 8.

In Fig. 8 the magnet consists, preferably, of two angle-pieces, the one mounted on the other, exposing toward each other a north and south pole, which are separated by an air-gap, which latter can be made narrower or wider. By this novel disposition of parts of a rotating armature provided with defined paths acted upon and reacting upon two energizing-circuits and at the same time providing an endless conductor to a permanent reacting field I obtain a sensitive integrating device and reduce the number of parts as well as the weight on the bearings and the total weight of the motor.

Figs. 9, $9^a$, and 10 show a still further modification of my armature, which is provided with a rim U, located in a horizontal plane, thereby strengthening the cylinder materially and providing a simple means for using a common horseshoe-magnet M for a braking device. It is an efficient and suitable means to replace the separate retarding-disk used in all meters. This rim may be separate ring U, which is fitted and slid over the rim of the cylinder. It may be located at the lower extremity or, as shown in Fig. 9[a], at any other place on the cylinder or may be cast on the cylinder. In Fig. 10 is shown an internal spider V, which has the further purpose of giving the cylinder additional support, especially during shipment, to prevent it from running untrue. This spider may be cast in or fitted in and may be made in the latter case of metallic or non-metallic material. Experiments have demonstrated, however, that a metallic spider or disk will answer just as well.

Figs. 11 and 12 show still a further improvement over the condition shown in Figs. 1, 2, and 7. As has been stated before, a slotted armature with a shunt-magnet having a wide air-gap is unsuitable for a good meter, and it is therefore desirable to make the reluctance of the magnet as small as can be made to obtain the best results. I therefore reduce the length of the core by causing it to act not on the cylinder itself, but on the flange, which is modified over that shown in Figs. 9 and 10. I provide slots in the ring which do not extend to the periphery. While in Figs. 1 and 2 the magnetic field of the series coil has been in a vertical plane and that of the shunt-circuit in a horizontal plane, the arrangement in Fig. 12 shows both fields acting in parallel vertical planes not intersecting with one another, the series coil acting on conductors in a vertical plane and the shunt-coil on a portion lying in a horizontal plane. This peculiar construction permits one to considerably reduce the length of magnet E and also reduce the air-gap between the poles. The shunt-magnet is of special construction to meet a number of requirements desired. Owing to the small air-gap it has to be subdivided if the shunt-coil should be a machine-wound one, which is preferable on account of reduced cost of manufacture.

Figs. 13 and 14 show in diagram still another armature modification, in which the same magnets and coils described with the armature shown in Figs. 11 and 12 may be used. The armature consists of a disk of aluminium securely mounted on shaft *l*. It is provided with slots N, which may be radial, but preferably have an angular direction, so that the conducting-strips formed do not stand vertical to the rings which they unite.

The series coil C is suspended in a plane parallel to the disk, either above or below it, while the shunt and permanent magnets have the same or similar disposition, as shown in Figs. 11 and 12. In this meter, like that shown in Figs. 11 and 12, both magnetic fields are in vertical non-intersecting planes. A series coil may be provided to either side of the laminated magnet to influence the disk or cylinder armature.

Fig. 15 shows a cylinder on its shaft resting in bearings, but its motion is restricted by means of springs W W, the index X moving in front of scale Y. In this form the device may be used as an indicating instrument for central-station uses. Fig. 16 is a diagram showing the application of this motor-meter for measuring bi or poly phase currents. The figure illustrates a double set of magnets C D E, as before described, the one set located in one circuit and the other, C D E, in the second circuit of a bi-phase system, depending on the number of phases the spool and magnets may be organized, so that a magnet and a series coil may be located in each circuit, or they may be reduced in number, provided that the different grouping will give a result equivalent to the actual energy consumed. Instead of causing the total amount of energy to pass, the meter may be arranged to conduct but one-half or any other fraction of the energy or current to be measured.

Experiments have shown that this meter will start with a fraction of an ampere, yet in large meters of great range it may be desirable to overcome or counterbalance the friction of the instrument. This I accomplish by displacement of or modifying the magnetic field of the magnet E or that of coil C. A similar result may be accomplished with the series coil at the expense of increased self-induction. Experiments with the last type of meters have fully demonstrated proportional readings without the aid of distortion and that excellent results are obtained without iron in the series coil by establishing two series fields, one placed on either side of the shunt-magnet, as indicated by the dotted spool, Fig. 14, all, however, having their independent field.

In Figs. 2 and 7 a special retarding device has been shown, which consists in providing a permanent magnet to influence either an independent conductor or a part of the armature. This separate retarding device may be entirely omitted, as is done in Fig. 1, in which case the retarding force must be furnished by the shunt-magnet E.

It will be seen in Figs. 2 and 7 that the magnet E covers not only a portion of the conductors R, but also the lower endless band of the cylinder. If a strong magnetic field is produced by magnet E, it will exert a similar influence on the lower end of the armature, as the magnet M' in Fig. 7.

My invention is open to numerous modifications, and I therefore do not wish to limit the same to the exact types or forms shown in the diagrams and drawings. For instance, the meter may be inserted in the primary circuit and not in the secondary of the consumption-circuit, which may be for light, power, or other purposes; and further, the device has been explained as an integrating-wattmeter, but it may be used as an indicating-wattmeter, voltmeter, and ammeter, and, lastly, while special armature forms have been shown others may be employed without departing from the nature of the invention.

Having now described my invention, what I desire to secure by Letters Patent is—

1. In an electric meter the combination of a main coil, and a shunt-coil establishing fields in non-intersecting planes, with an endless conductor provided with perforations, a spindle for said endless conductor, a counting-train adapted to engage with said spindle, and a retarding-magnet reacting on said rotary conductor, as and for the purpose described.

2. In an electric meter the combination of a perforated conductor adapted to rotate, with a shunt-winding, mounted on a magnetic core, a coreless series coil, both coils acting upon said rotary conductor, a counting-train for registering the revolutions of said conductor, and a retarding device acting on said conductor.

3. In an electric-meter system the combination of a suitable source, a distributing-circuit and current-consuming devices, with a meter interposed between said source and said devices, consisting of a perforated conductor adapted to rotate, a coreless coil, a second coil, a magnetic circuit for said second coil of low reluctance, and means for retarding the speed of said conductor in proportion to the currents passed through the circuit.

4. In an electric meter the combination of two sets of coils producing magnetic fields in non-intersecting planes with a perforated conductor exposed to the actions and reactions of said two sets of coils, a counting-train and retarding device acting directly on said armature, as, and for the purpose described.

5. In an electric-meter system the combination of a suitable source and a consumption-circuit with a meter interposed between the source and said consumption-circuit, consisting of a perforated endless conductor, mounted on a shaft adapted to rotate, a main energizing-coil acting on said conductor in a given plane, a shunt-coil acting on said conductor in a different plane, a registering device engaging with said shaft, and a retarding device reacting on said conductor.

6. In an electric meter the combination of two sets of energizing-coils of different phase, with a perforated endless conductor acted upon by said coils in different planes, a registering device, and a retarding device adapted to and reacting directly upon said endless conductor.

7. In a bell-shaped armature the combination of a cylinder with one or two sleeves for attaching it rigidly to a shaft, adapted to be mounted movably in supports, and slots or holes provided in said cylinder, as, and for the purpose described.

8. In an armature for electric meters the combination of a bell-shaped metallic conductor, with a support located at one extremity of said bell and a second support located within said bell.

9. In an armature for electric meters the combination of a cylinder mounted rigidly on a shaft adapted to be movable in its bearings, with a ring or flange of conducting material, encircling said cylinder in a plane at right angles, as, and for the purpose described.

10. In an armature for electric meters the combination of a shaft with a cylinder or bell attached thereto, and a ring lying in a plane at right angles to the shaft attached to said cylinder or bell.

11. An armature for electric meters, consisting of two parallel endless conductors, conducting-strips uniting said endless conductors, said strips being angularly disposed relatively to said endless conductors, and a rotatable shaft upon which said conductors are mounted.

12. An armature for electric meters consisting of two endless conductors, and conducting-strips angularly disposed to said endless conductors connecting the two latter with one another.

13. An armature for electric meters consisting of two rings of electrical conductors and conducting-strips angularly disposed to said rings connecting them to one structure.

14. In an electric meter the combination of an armature mounted on a shaft and adapted to rotate, with an electromagnet influencing said armature at one end or plane, a laminated block located inside of said armature for establishing a magnetic circuit of small reluctance, a main energizing-coil influencing said armature at a different end, or another plane from said magnet, and a registering device adapted to engage with the shaft, as, and for the purpose described.

15. In an electric meter the combination of a series-energizing circuit and a shunt-energizing circuit with an armature consisting of two conducting-rings and conducting-strips, connecting said rings with one another, a rotatable shaft for said armature, a registering-train operated by said armature-shaft, and a retarding device acting on a conducting-ring of said armature, as, and for the purpose described.

16. In an electric meter the combination of two or more energizing-circuits with a slotted or perforated conductor, adapted to rotate, a metallic ring encircling said conductor in a horizontal plane and a retarding device acting on said metallic ring.

17. In an electric meter and in combination with two or more energizing-circuits of a perforated armature acted upon by said circuits, a retarding device adapted to act directly upon perforated, as well as non-perforated parts of said armature, and a registering-train, as and for the purpose described.

18. An armature for electric motors consist-

ing of a metallic sheet provided with slots or perforations and a band at either end of said slots connecting the metal strips created by said perforations.

19. In an armature for alternating-current electric motors the combination of a suitable core, with conducting-strips, and a band at each end of said conducting-strips, connecting them to a single structure, as and for the purpose described.

20. In an armature for electric meters the combination of a bell-shaped conductor, with means for supporting said bell at one extremity by a suitable shaft, and a second and removable support for said armature to said shaft, located at or near the other extremity of said bell.

21. In an electric meter the combination of a conductor, partially perforated and adapted to rotate, with one or more series coils acting on said conductor, a laminated shunt-magnet adapted to act simultaneously on perforated and non-perforated parts of said armature, and a registering device engaging with said shaft, as, and for the purpose described.

22. In an armature for electric motors the combination of a core with a metallic sheet provided with slots or perforations whereby metallic strips are created and an endless conductor at either end of said strips connecting them to one structure, as and for the purpose described.

23. In an electric meter the combination of a main coil adapted to establish a magnetic field, with a shunt-magnet for establishing a second field, an armature located between the poles of said magnet and a core for concentrating the second-named magnetic field to the exclusion of the first, located within said armature.

24. In an electric meter the combination of a main coil, with a shunt-magnet, an armature, and a core located within said armature, the mass of said core being disposed at one side of the axis of said armature.

In testimony that I claim the foregoing as my invention I have signed my name, in presence of two witnesses, this 1st day of December, A. D. 1897.

LUDWIG GUTMANN.

Witnesses:
DAVID ROSS,
G. G. LUTHY.